Alerts, Notices, and Case Reports

Tension Pneumoperitoneum

STEPHANIE Y. CHAN, MD
CARL M. KIRSCH, MD
WILLIAM A. JENSEN, MD
JOHN SHERCK, MD
San Jose, California

PNEUMOPERITONEUM IS a well-known consequence of gastrointestinal perforation, mechanical ventilation, and abdominal operations. Free intraperitoneal gas is usually a marker of underlying disease and does not in itself pose a hazard to a patient. Tension pneumoperitoneum, on the other hand, is a rare complication in which intraperitoneal gas, under pressure, causes hemodynamic and ventilatory compromise, necessitating urgent intervention. We report the case of a mechanically ventilated patient in whom tension pneumoperitoneum developed and describe a simple test that confirmed that the pneumoperitoneum resulted from pulmonary barotrauma.

Report of a Case

The patient, a 60-year-old woman, was admitted to the intensive care unit for hemoptysis and renal failure. She had been healthy until three months before admission, when weakness and anorexia developed, with weight loss. Her hematocrit was 0.25 (25%), and her serum creatinine level was 221 μmol per liter (2.5 mg per dl). An upper gastrointestinal series was normal, and a stool occult blood test was negative. Two weeks before admission, shortness of breath developed, and she had hemoptysis, night sweats, chills, and fever. On admission, her temperature was 38.7°C (101.6°F), her blood pressure was 150/70 mm of mercury, her pulse rate was 108 beats per minute, her respirations were 24 per minute, and oxygen saturation was 94% while the patient was breathing supplemental oxygen at 4 liters per minute by nasal cannula. She was thin, ill-appearing, and in moderate respiratory distress. Her lungs had diffuse rales, there was no cardiac murmur, and her abdomen was unremarkable. Relevant laboratory data included a hematocrit of 0.17 (17%), serum creatinine level of 574.6 μmol per liter (6.5 mg per dl), and a urinalysis that showed erythrocyte casts. An arterial blood gas measurement showed a pH of 7.35, a P_{CO_2} of 35 mm of mercury, and a P_{O_2} of 53 mm of mercury with the patient breathing room air.

Her chest radiograph showed bilateral diffuse alveolar infiltrates with sparing of the left upper lobe (Figure 1).

The combination of pulmonary hemorrhage and glomerulonephritis strongly suggested an autoimmune disease such as Wegener's granulomatosis or antiglomerular basement membrane disease. The patient was started on a regimen of intravenous ceftazidime and clindamycin and treated empirically for autoimmune diseases with daily plasmapheresis and the administration of cyclophosphamide and high doses of methylprednisolone sodium succinate. She was intubated on the third hospital day for respiratory fatigue and progressive oxygen hemoglobin desaturations as low as 80% while receiving supplemental oxygen. A percutaneous needle biopsy of the left kidney showed crescentic glomerulonephritis without vasculitis, but there were no glomeruli available for immunofluorescent staining. On the fourth hospital day, a right tension pneumothorax developed after the patient had bronchoscopy and bronchoalveolar lavage. She was also noted to have a pneumomediastinum and massive subcutaneous emphysema. Insertion of two chest tubes returned the patient's hemodynamic and ventilatory status to baseline.

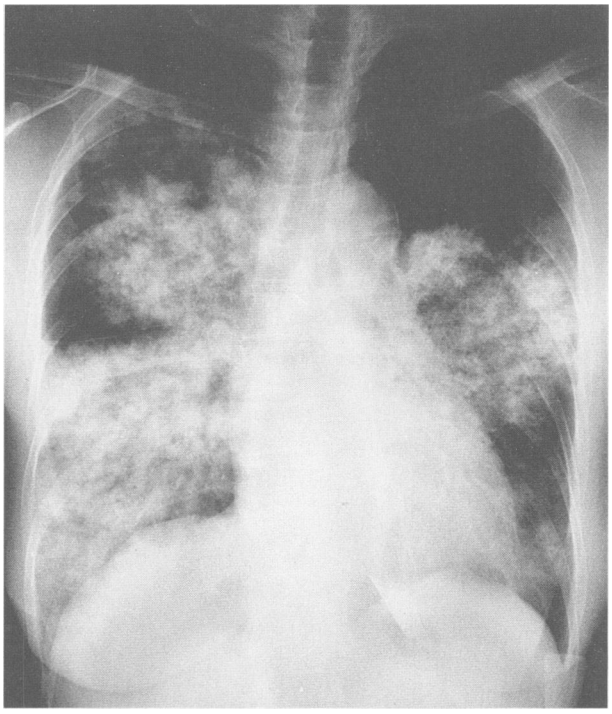

Figure 1.—The patient's admission chest radiograph shows diffuse alveolar infiltrates.

On the 13th hospital day, while chest tubes and mechanical ventilation were still in use, tense abdominal distention suddenly developed. The patient's blood pressure dropped from 140/60 to 80/50 mm of mercury, her pulse rate increased from 120 to 150 per minute, and her oxygen hemoglobin saturation decreased from 100% to 82% on an inspired oxygen fraction of 80%. The mechanical ventilator was set at a tidal volume of 500 ml, a positive end-expiratory pressure of 5 cm of water, and a pressure support of 10 cm of water in the intermittent mandatory ventilation mode at a rate of 22 per minute. The peak inspiratory pressure increased from 50 to greater than 100

(Chan SY, Kirsch CM, Jensen WA, Sherck J: Tension pneumoperitoneum. West J Med 1996; 165:61-64)

From the Department of Medicine (Drs Chan, Jensen, and Kirsch) and the Department of Surgery (Dr Sherck), Santa Clara Valley Medical Center, San Jose, California.

Reprint requests to Stephanie Y. Chan, MD, Dept of Medicine, Santa Clara Valley Medical Center, 751 S Bascom Ave, San Jose, CA 95128.

Figure 2.—This abdominal radiograph shows tension pneumoperitoneum with massive free intraperitoneal gas causing medial displacement of the liver and elevation of the diaphragm.

cm of water, the abdomen became even more distended, and ventilation was greatly impaired. The patient was removed from the mechanical ventilator, and AmbuBag ventilation was attempted without improvement. An emergency abdominal film revealed a massive amount of intraperitoneal air with medial shifting of the liver and the elevation of both hemidiaphragms (Figure 2). A chest radiograph showed the endotracheal tube and chest tubes in good position, without recurrent pneumothorax. The patient was on nasogastric suction throughout the event, without any improvement. A No. 16-gauge intravenous catheter was inserted percutaneously into the peritoneal cavity in the right upper abdominal quadrant, and an immediate rush of odorless gas was accompanied by pronounced improvement in the patient's hemodynamics and oxygenation. This temporary catheter was then exchanged over a guide wire for a 10F pigtail soft biliary drainage catheter with end and side holes. On two occasions, the abdominal drainage catheter became kinked under the patient, causing her abdomen to become rapidly tense and ventilation to become difficult until catheter patency was restored.

Perforation of the gut as a cause of the tension pneumoperitoneum was deemed unlikely because the patient continued to have normal bowel sounds. Instead, we thought that the gas causing the pneumoperitoneum originated from the thoracic cavity because such rapid, pressurized gas accumulation could be generated by the mechanical ventilator. We therefore sampled gas simultaneously from the chest tubes and the abdominal drain with 30-ml silicone-coated glass syringes and obtained radial arterial blood specimens while the patient was breathing 90% oxygen. All gas and blood specimens were analyzed with a CIBA-Corning model No. 288 blood gas system (CIBA-Corning, Medfield, Massachusetts) on a day when the barometric pressure was 752 mm of mercury and the patient's temperature was 37°C (98.6°F). The partial pressures of oxygen in the gas from the chest tubes, abdominal drain, and arterial blood are shown in Table 1.

A complete workup—including routine bacterial and acid-fast bacillary cultures; serologic tests for Goodpasture's syndrome, Wegener's granulomatosis, and systemic lupus erythematosus; bronchoscopy; and open-lung biopsy—failed to reveal the cause of the patient's respiratory and renal failure. A renal biopsy revealed nonspecific immune complex-mediated disease, and the only positive serologic test was for hepatitis B surface antigen. The patient continued to deteriorate, and *Candida* species sepsis developed, necessitating support with dopamine and amphotericin B. The patient died on the 18th hospital day, and permission for an autopsy was not granted.

TABLE 1.—*Measurements of Partial Pressure of Oxygen in a 60-Year-Old Patient With Tension Pneumoperitoneum*

Site	Partial Pressure of Oxygen, mm of mercury
Chest tube #1	627
Chest tube #2	633
Abdominal drain	632
Radial artery	67

Discussion

Tension pneumoperitoneum from a grenade-induced gastric perforation was first reported in 1917 by Oberst, a German physician.[1] He postulated that a valvular mechanism, possibly caused by the liver overlying a perforation in the stomach, allowed air into but not out of the intraperitoneal cavity. A massive accumulation of free air would result in elevation of the diaphragm, with a consequent restriction of lung volumes and a decrease in venous return, causing hemodynamic instability. Studies in dogs have shown that an elevation of intra-abdominal pressures leads to a reduction in cardiac output, stroke volume, and arterial Po_2 and an increase in systemic vascular resistance.[2,3]

Abdominal fullness and dyspnea usually occur with tension pneumoperitoneum. The findings of a physical examination are notable for a grossly distended, barrel-shaped abdomen, although this finding may be masked in morbidly obese persons. Bowel sounds are usually present but distant, and tenderness is minimal unless peri-

TABLE 2.—*Causes of Tension Pneumoperitoneum Reported in the Literature*

Reference	Cases, No.	Source	Cause
Lagundoyle and Itayem, 1970[20]	2	Gastrointestinal	Abdominal-pelvic tuberculosis; puerperal sepsis, abscess
Hall, 1971[17]	2	Gastrointestinal	Colostomy leak
Thiele, 1973[30]	2	Gastrointestinal	Compressed air injury of colon
Echave et al, 1975[14]	1	Gastrointestinal	Duodenal ulcer perforation
Ogg and Davidson, 1975[24]	1	Gastrointestinal	Perforation from EGD
Addison and Broughton, 1976[11]	4	Gastrointestinal	Cecal perforation from pseudo-obstruction; perforation from sigmoid cancer (2 cases); duodenal ulcer perforation
Irwin, 1976[19]	1	Gastrointestinal	Ileocolic anastomosis leak
Linch et al, 1979[22]	1	Gastrointestinal	Gastric perforation from CPR
Gimmon et al, 1980[16]	1	Gastrointestinal	Ischemic colitis
Hutchinson et al, 1980[8]	1	Gastrointestinal	Gastric perforation from aerophagia
Taub et al, 1980[29]	1	Gastrointestinal	Gastric ulcer perforation with EGD
Roberts et al, 1981[26]	1	Gastrointestinal and pulmonary	Traumatic gastric perforation with mechanical ventilation
Mills et al, 1983[23]	1	Gastrointestinal	Gastric rupture from CPR and esophageal intubation
Olinde et al, 1983[5]	1	Gastrointestinal	Gastric ulcer perforation
Ehrlich et al, 1984[15]	1	Gastrointestinal	Perforation from colonoscopy
Ballet and Michel, 1985[12]	1	Gastrointestinal	Oxygen flow into nasogastric tube
Biert et al, 1987[9]	1	Gastrointestinal	Gastric perforation from aerophagia
Higgins et al, 1988[18]	1	Gastrointestinal	Ileorectal anastomosis with aerophagia
Ralston et al, 1989[25]	1	Pulmonary	Mechanical ventilation
Yip et al, 1989[32]	1	Urinary tract	Bladder catheter left open to air
Cameron et al, 1991[6]	1	Gastrointestinal	Gastric rupture from CPR
Yip et al, 1991[31]	1	Gastrointestinal	Colonic perforation from polypectomy
Barnett et al, 1992[13]	1	Gastrointestinal	Cecal perforation from colonoscopy
Winer-Muram et al, 1993[7]	2	Pulmonary	Mechanical ventilation
Critchley and Rowbottom, 1994[10]	1	Pulmonary	Mechanical ventilation
Schwarz et al, 1994[27]	2	Pulmonary	Mechanical ventilation
Serdyn and Lake, 1994[28]	1	Gastrointestinal	Gastric ulcer perforation
Lal et al, 1995[21]	1	Pulmonary	Tracheal tear, mechanical ventilation

CPR = cardiopulmonary resuscitation, EGD = esophagogastroduodenoscopy

toneal inflammation is also present.[4] Evidence of increased intra-abdominal pressure, such as rectal prolapse, may be present, as may crepitus due to subcutaneous air in the abdominal wall.[5] Examination of the lower extremities and genitals may reveal signs of venous congestion, such as edema and, in one reported case, priapism.[6] Pelvic vein thrombosis has been reported with tension pneumoperitoneum.[7] Acute aortic occlusion is another possible complication, with the loss of pulses, sensation, and motor function in the lower extremities.[5] As the pneumoperitoneum progresses, the patient may become hypotensive, tachycardic, and cyanotic and may suffer cardiac or respiratory arrest.[5,8-10]

We reviewed 36 reports of adult cases covering the past 25 years and found that the causes of tension pneumoperitoneum can be divided into gastrointestinal (27 cases), pulmonary (7 cases), a combination of gastrointestinal and pulmonary (1 case), and urologic causes (1 case).[5-32] Table 2 lists the more specific causes of or contributing factors to tension pneumoperitoneum. In more recent years, a growing number of cases of this disorder have been caused or exacerbated by positive-pressure ventilation. Air from a pneumothorax or pneumomediastinum can penetrate the diaphragm through normal apertures into the retroperitoneal space.[33] From there, it can rupture into the intraperitoneal cavity. Other causes of tension pneumoperitoneum include endoscopy (both esophagogastroduodenoscopy and colonoscopy),[12,15,24,29,32] gastric or duodenal ulcer perforation,[5,11,14,28,29] aerophagia or air insufflation of the gastrointestinal tract,[8,12,30] and gastric rupture due to cardiopulmonary resuscitation.[6,22,23] An unusual case of tension pneumoperitoneum occurred in a woman with transitional cell carcinoma of the bladder who had a Foley catheter inserted that was left open to the air.[32]

The diagnosis of tension pneumoperitoneum is based on clinical signs and an abdominal radiograph showing intraperitoneal gas with upward displacement of the diaphragm and medial displacement of the liver ("saddlebag sign").[8] The cause of the tension pneumoperitoneum may not be immediately apparent. If perforation of the gastrointestinal tract is suspected, exploratory laparotomy may be warranted. In mechanically ventilated patients, however, a search should be done for accompanying signs of barotrauma, such as pneumothorax, pneumomediastinum, or subcutaneous emphysema. In a review of 28 cases of pneumoperitoneum (though not necessarily due to tension) associated with mechanical ventilation, 27 patients had other signs of barotrauma.[33] Tension pneumoperitoneum caused by barotrauma is also usually associated with high peak end-expiratory pressures and tidal volumes.[33] We describe a simple test, done once before by Ralston, that clearly demonstrates the source of the intraperitoneal gas.[25] We measured the partial pressure of oxygen in gas taken from the pleural and peritoneal

spaces and showed that it was the same as that expected in the trachea and was far greater than that expected in ambient air. The results of this test enabled us to determine with certainty that the source of the intraperitoneal gas causing tension pneumoperitoneum in our patient was from the lung, and an unnecessary laparotomy was avoided. The only gastrointestinal source that could practically cause a tension pneumoperitoneum with similar Po_2 measurements in gas specimens would be a tracheoesophageal fistula, but there was no evidence of gastrointestinal dilatation in our patient.

Regardless of the cause, the emergent treatment of tension pneumoperitoneum in an unstable patient should be percutaneous catheter insertion or, if time permits, drain placement to relieve the intraperitoneal pressure. This maneuver usually results in immediate hemodynamic and ventilatory improvement.* Thereafter, treatment depends on the specific cause. Although laparotomy may be necessary if a gastrointestinal cause is suspected, a surgical procedure should be avoided if the gas has dissected into the peritoneal cavity from the lungs. Patients with tension pneumoperitoneum due to pulmonary barotrauma may require continuous intraperitoneal catheter drainage for the duration of positive-pressure ventilation.

REFERENCES

1. Oberst A: Das spannungspneumoperitonaion. Zentralbl Chirurg 1917; 44:354-355

2. Barnes GE, Laine GA, Giam PY, Smith EE, Granger HJ: Cardiovascular responses to elevation of intra-abdominal hydrostatic pressure. Am J Physiol 1985; 248:R208-R213

3. Hirsch S, Kelly KM, Benjamin E, Gentili DR, Premus G, Iberti TJ: The hemodynamic effects of increased intra-abdominal pressure in the canine model (Abstr). Crit Care Med 1987; 15:423

4. Singer HA: Valvular pneumoperitoneum. JAMA 1932; 99:2177-2180

5. Olinde AJ, Carpenter D, Maher JM: Tension pneumoperitoneum: A cause of acute aortic occlusion. Arch Surg 1983; 118:1347-1350

6. Cameron PA, Rosengarten PL, Johnson WR, Dziukas L: Tension pneumoperitoneum after cardiopulmonary resuscitation. Med J Aust 1991; 155:44-47

7. Winer-Muram HT, Rumbak MJ, Bain RS: Tension pneumoperitoneum as a complication of barotrauma. Crit Care Med 1993; 21:941-943

8. Hutchinson GH, Alderson DM, Turnberg LA: Fatal tension pneumoperitoneum due to aerophagy. Postgrad Med J 1980; 56:516-518

9. Biert J, ter Haar AM, Eggink WF: Tension pneumoperitoneum, an unusual complication of perforation of the stomach (Letter). Neth J Surg 1987; 39:134-135

10. Critchley LA, Rowbottom S: Fatal tension pneumoperitoneum with pneumothorax. Anaesth Intensive Care 1994; 22:298-299

11. Addison NV, Broughton AC: Tension pneumoperitoneum: A report of 4 cases. Br J Surg 1976; 63:877-880

12. Ballet TH, Michel L: Gastric rupture: A danger of postoperative oxygenation with a nasal catheter. Int Surg 1985; 70:265-266

13. Barnett T, McGeehin W, Chen C, Brennan E: Acute tension pneumoperitoneum following colonoscopy. Gastrointest Endosc 1992; 38:99-100

14. Echave V, Flores M, Ogilvy WL: Tension pneumoperitoneum: Case report and review of the literature. Can J Surg 1975; 18:585-588

15. Ehrlich CP, Hall FM, Joffe N: Postendoscopic perforation of normal colon in an area remote from instrumentation—with secondary tension pneumoperitoneum. Gastrointest Endosc 1984; 30:190-191

16. Gimmon Z, Berlatzky Y, Freund U: Tension pneumoperitoneum complicating nongangrenous nonocclusive ischemic colitis. Am J Proctol Gastroenterol Colon Rectal Surg 1980; 31:8,13,24

17. Hall R: Delayed tension pneumoperitoneum after colostomy closure. Br J Surg 1971; 58:574-576

18. Higgins JRA, Halpin DMG, Midgley AK: Tension pneumoperitoneum: A surgical emergency. Br J Hosp Med 1988; 39:160-161

19. Irwin T: Postoperative tension pneumoperitoneum, a complication of colonic anastomosis: Report of a case. Dis Colon Rectum 1976; 19:68-70

20. Lagundoyle SB, Itayem SO: Tension pneumoperitoneum. Br J Surg 1970; 57:576-580

21. Lal AB, Kumar N, Sami KA: Tension pneumoperitoneum from tracheal tear during pharyngolaryngoesophagectomy. Anesth Analg 1995; 80:408-409

22. Linch D, McDonald A, McNicol L: Tension pneumoperitoneum complicating cardiac resuscitation. Intensive Care Med 1979; 5:93-94

23. Mills SA, Paulson D, Scott SM, Sethi G: Tension pneumoperitoneum and gastric rupture following cardiopulmonary resuscitation. Ann Emerg Med 1983; 12:94-95

24. Ogg TW, Davidson AI: Respiratory failure following gastroscopy. Anaesthesia 1975; 30:194-198

25. Ralston C, Clutton-Brock TH, Hutton P: Tension pneumoperitoneum. Intensive Care Med 1989; 15:532-533

26. Roberts RB, Blake BC, Bruggeman GE: Tension pneumoperitoneum—A cause of ventilatory obstruction. Anesthesiology 1981; 55:326-327

27. Schwarz RE, Pham SM, Bierman MI, Lee KW, Griffith BP: Tension pneumoperitoneum after heart-lung transplantation. Ann Thorac Surg 1994; 57: 478-481

28. Serdyn C, Lake APJ: Tension pneumoperitoneum. Anesth Intensive Care 1994; 22:626-627

29. Taub SJ, Nagurka C, Raskin JB: Tension pneumoperitoneum as a nontraumatic complication of upper gastrointestinal endoscopy. Gastrointest Endosc 1980; 26:153-154

30. Thiele BL: Compressed air injury of the colon: A report of two cases. Aust N Z J Surg 1973; 43:49-51

31. Yip AWC, Chow WC, Chan J: Tension pneumoperitoneum after colonoscopic polypectomy (Letter). Endoscopy 1991; 23:241

32. Yip A, Lau WY, Wong KK: Tension pneumoperitoneum: An unusual urologic cause. Br J Urol 1989; 64:199-200

33. Hillman KM: Pneumoperitoneum—A review. Crit Care Med 1982; 10:476-481

*References 7, 9, 13, 17, 18, 22, 27, 29, and 32.

Wegener's Granulomatosis Presenting as Dilated Cardiomyopathy

JOHN D. DAY, MD
KRISTIN E. ELLISON, MD
INGELA SCHNITTGER, MD
MARK G. PERLROTH, MD
Stanford, California

WEGENER'S GRANULOMATOSIS is characterized by necrotizing, vasculitic, granulomatous lesions of the kidneys and upper and lower respiratory tract. Clinically notable cardiac involvement with the disease process is only rarely encountered. We describe the case of a patient who initially presented with dilated cardiomyopathy and who was later found to have elevated levels of antineutrophil cytoplasmic antibodies (c-ANCA); renal and pulmonary biopsy findings were consistent with Wegener's granulomatosis.

Report of a Case

The patient, a 57-year-old woman, presented with dyspnea on exertion and paroxysmal nocturnal dyspnea for two years. Eighteen months after her symptoms started, she was noted to have proteinuria and mild renal insufficiency. In July 1995, she underwent a cardiac evaluation

(Day JD, Ellison KE, Schnittger I, Perlroth MG: Wegener's granulomatosis presenting as dilated cardiomyopathy. West J Med 1996; 165:64-66)

From the Division of Cardiology, Department of Medicine, Stanford University Medical Center, Stanford, California.

Reprint requests to Mark G. Perlroth, MD, Stanford University Medical Center, Falk Research Center CV-263, 300 Pasteur Dr, Stanford, CA 94305-5246.